

SMART HELMET: A LIFE-SAVING CYBER-PHYSICAL SYSTEM BASED ON EDGE COMPUTING⁺

Manoj Saxena, Prateek Kumar, and Naresh K. Sehgal

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AGENDA

- Background
- Smart Helmets
- Limitations
- Our Solution
- Future Needs

BACKGROUND

- Motorcycle helmets protect rider's head in an accident.
- Invented in 1914 by Eric Gardner [1], a medical officer at the Brooklands Racetrack.
- In 1941, Sir Hugh Cairns, an Australian neurosurgeon, published a research paper
 - In the British Medical Journal [2] showing the importance of helmets in saving lives.

[1] How the crash helmet originated, Motor Cycle magazine, June 22nd, 1922

[2] Hugh Cairns, Head Injuries in Motor-cyclists. The Importance of the Crash Helmet, British Medical Journal, October 1941.

<https://doi.org/10.1136/bmj.2.4213.46>

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SMART HELMETS



For applications such as fall detection, accident prevention, health monitoring, alcohol check, location reporting, and distress alerting etc.

- 1. In-helmet Communications:** Bluetooth and wireless mesh networks (WMN) to communicate with devices like smartphone and other riders on the same network.
- 2. Visual Displays:** Smart technologies provide visual information to riders about the road conditions ahead.
- 3. Built-in cameras:** Cameras are embedded in the helmet to capture ride footage and record road incidents.
- 4. Intelligent Noise Control:** It helps reduce the sound of the bike, other vehicles, and wind noise.
- 5. Emergency Location Broadcast:** It allows helmets to broadcast a rider's location to pre-defined numbers in an emergency. It is helpful for solo riders in case of a crash.
- 6. Carbon Fibers:** Carbon Fiber is robust, durable, and lightweight. Helmets made from Carbon fiber are more comfortable to ride in for long periods.
- 7. Embedded Sensors:** To detect environmental hazards, observe rider activity, measure physiological parameters, and alert stakeholders in case of an accident.



• LIMITATIONS

Limit large-scale adoption of these helmets

Limited Computation Capability: converting analog data from sensors to digital, which is then communicated to the Cloud server for processing.

Limited Storage Capacity: Not designed to store large datasets.

Privacy Concerns: Vulnerable to cyber-attacks, can compromise the security and privacy of the rider's data being collected and transmitted.

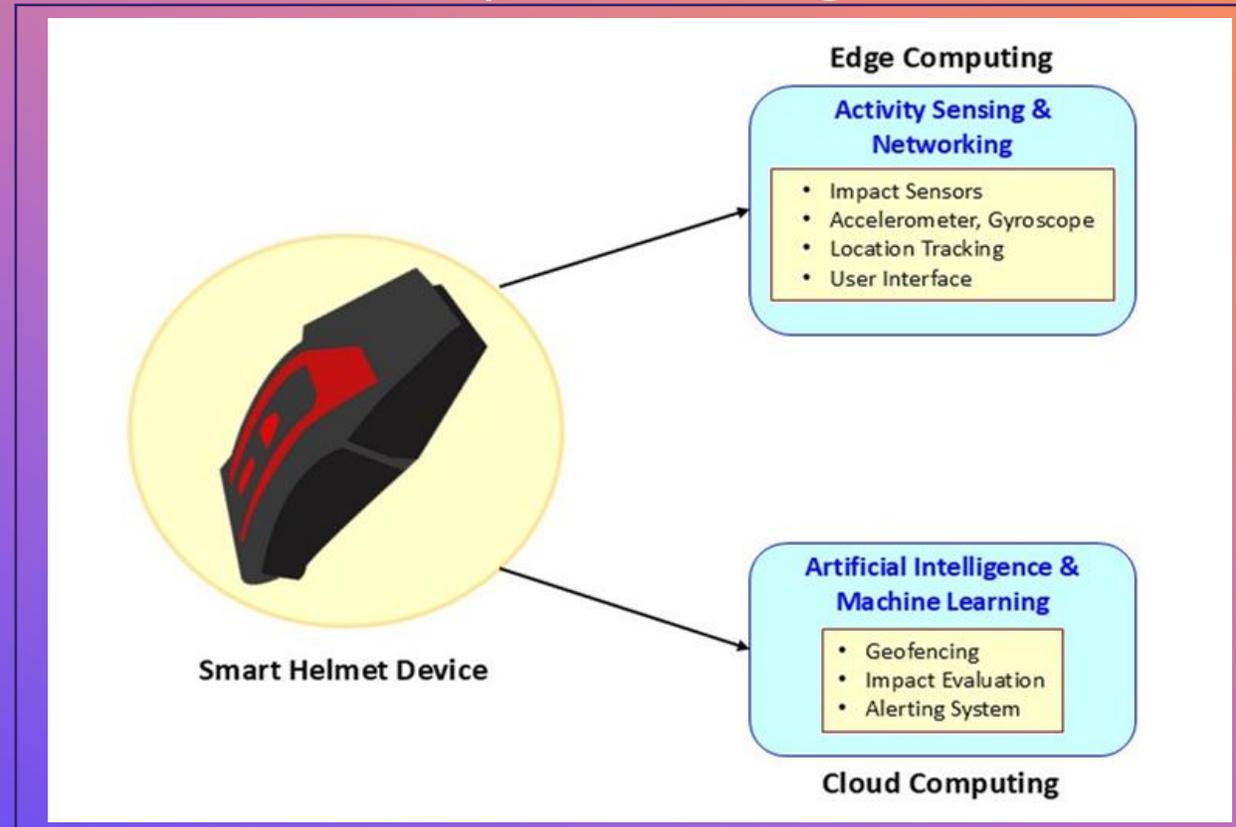
Security Risks: Hacking or unauthorized access, leading to data breaches.

Reliability and Downtime Risks: Rely on continuous connectivity and a power supply to function effectively for most applications.

High Costs: More than regular helmets, resulting in higher deployment costs.

OUR SOLUTION

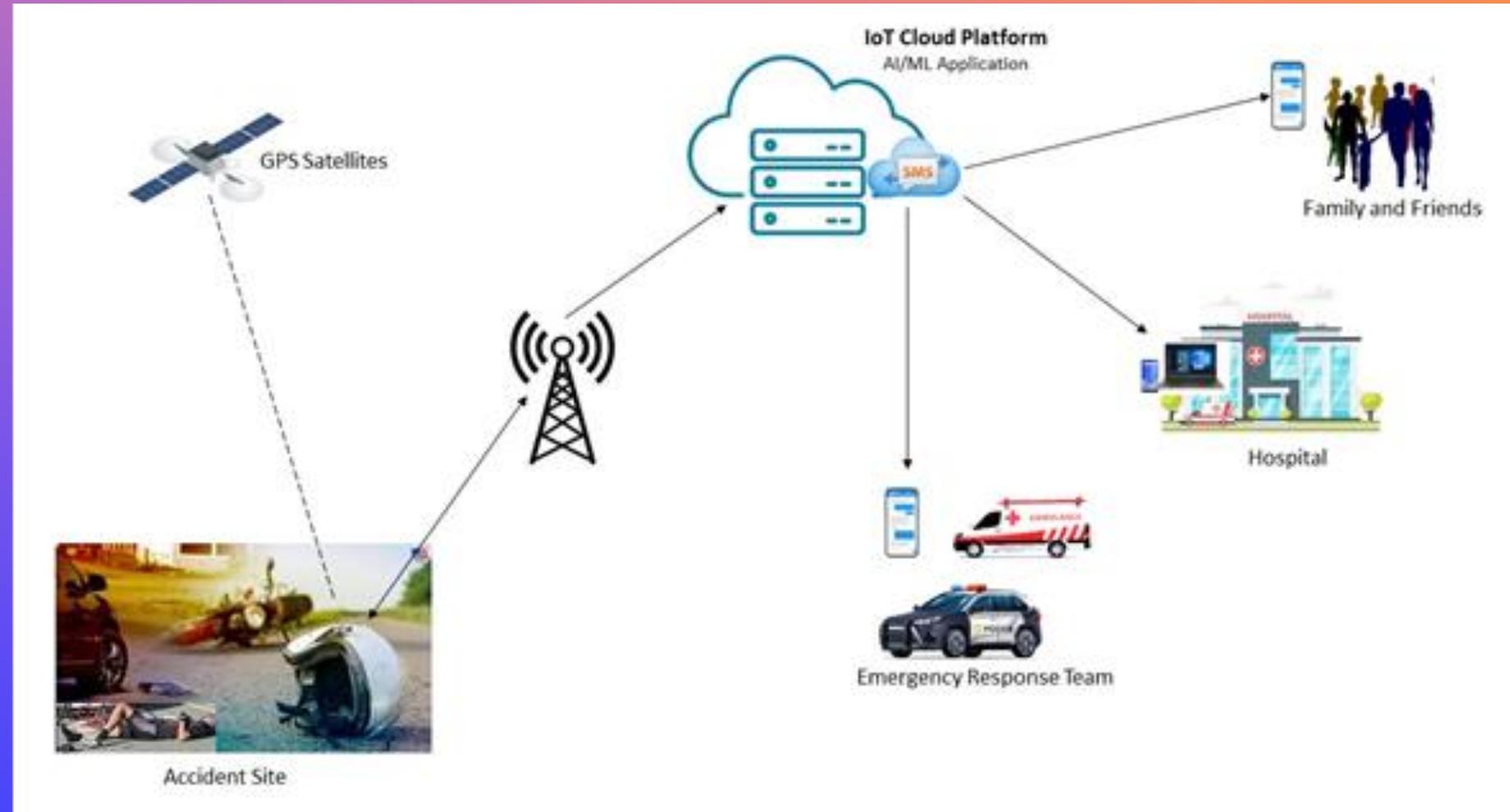
- An IoT-enabled Helmet with an AI-enabled application to provide immediate medical help.
- It integrates an Accelerometer, Gyroscope, LDR, IR, barometric pressure, and altitude sensors, communicates with smartphone using Bluetooth



SMART HELMET SYSTEM

- The data generated from sensors is collated by the smartphone and forwarded to the Cloud server.
- Analytics are performed by an AI engine in the Cloud.

- Rider gets constant feedback about the traffic and ride performance.
- In an accident, severity is computed and location conveyed to the family/friends or emergency services



SMART HELMET SYSTEM COMPONENTS

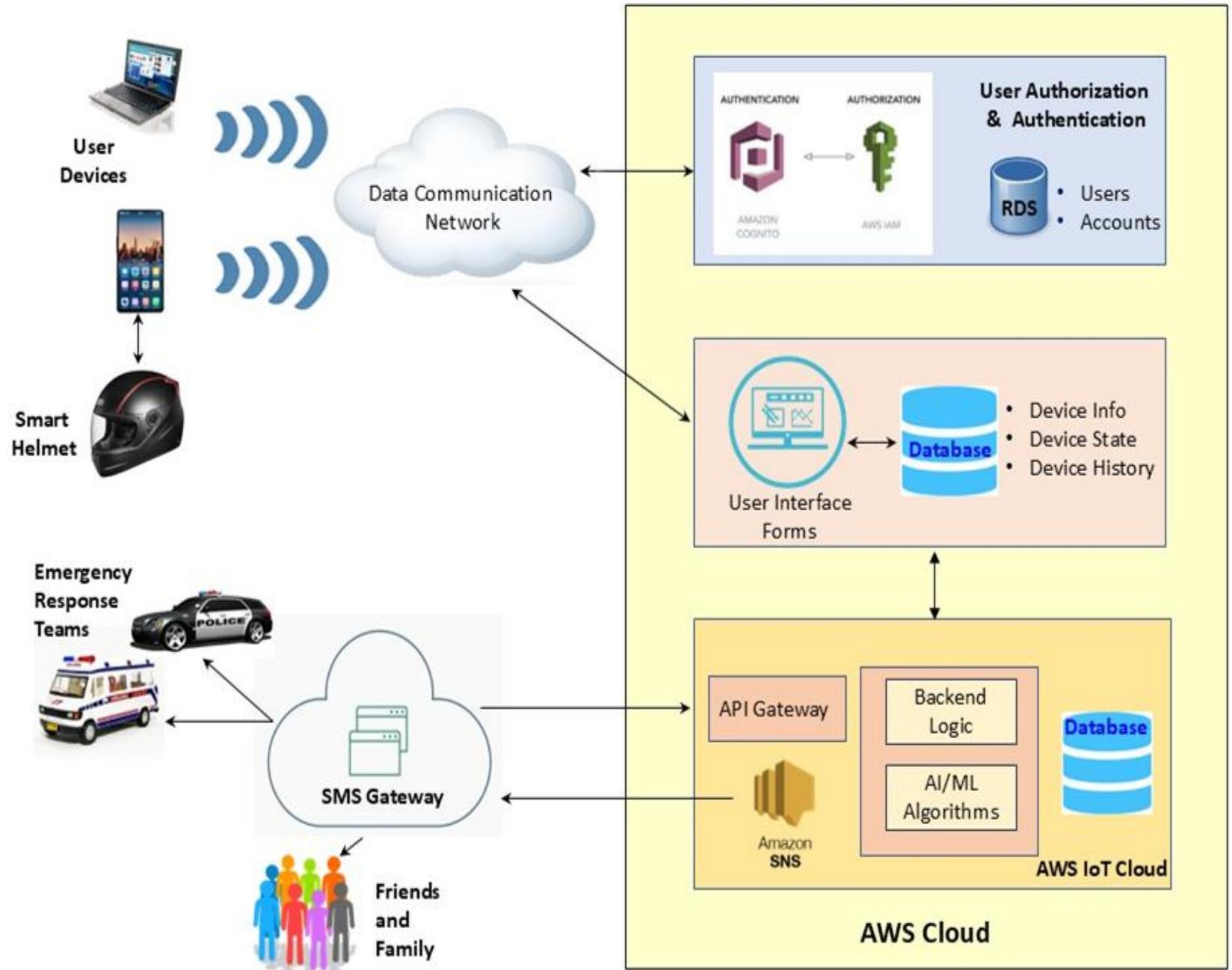
Server- side Components

1. Authentication and Authorization
2. APIs for Mobile Apps
3. Dashboard Functionality
4. Business Logic
5. Artificial Intelligence and Machine Learning Model
6. Communication Interface
7. Database

Client-side Components

1. Mobile Apps for IOS and Android
2. Smart Helmet Device
3. User Dashboard
4. User Application Interface (for web apps)

N FLOW



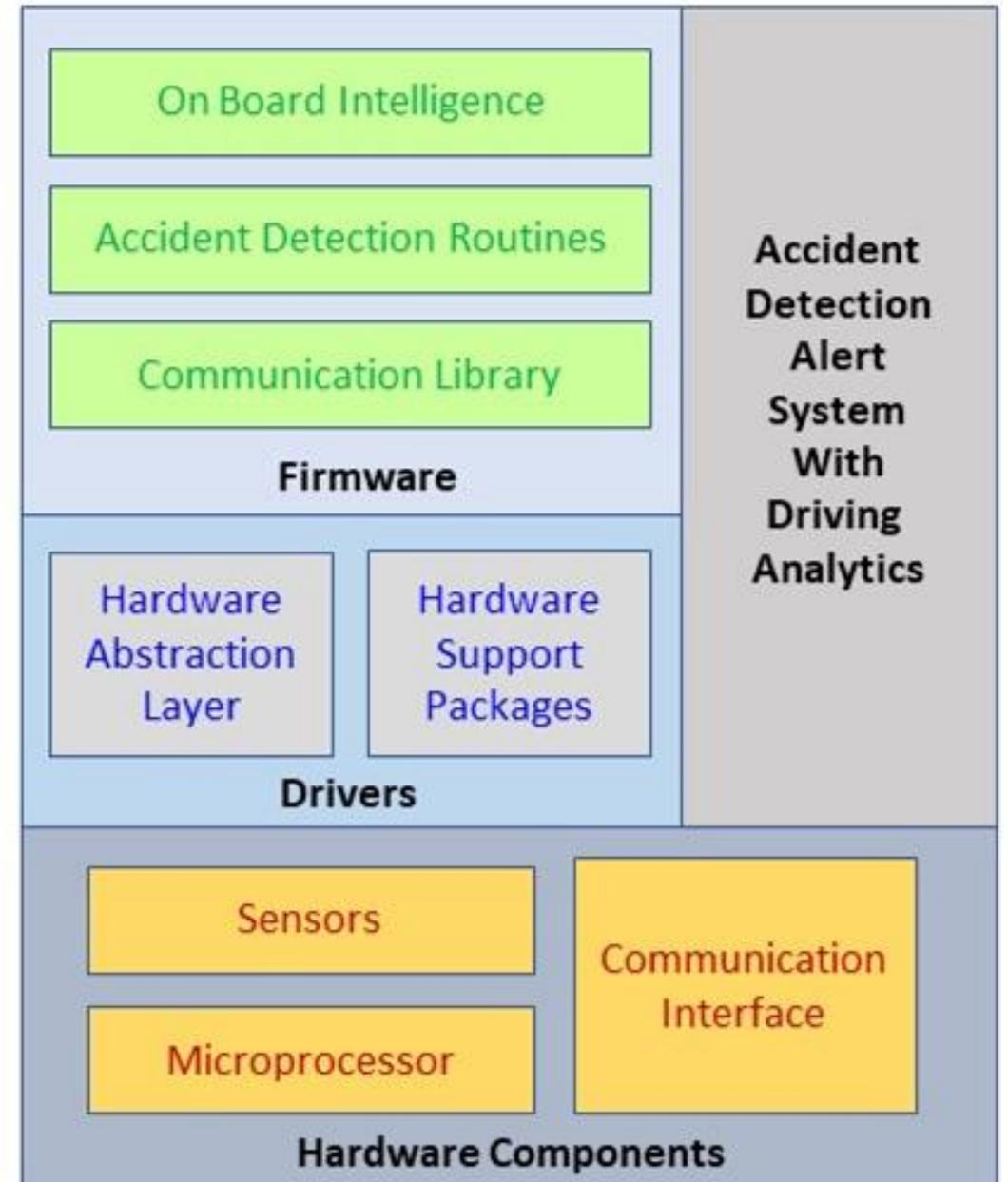
DEVICE TECHNOLOGY STACK

Hardware Components: Onboard processor and sensors to detect changes in acceleration, height, speed, location, etc.

Drivers: Software code to communicate with the sensors, collect specific inputs, and convert them to digital format.

Firmware: Functionality to detect an accident occurrence based on data from sensors, intelligence to ignore false alarms/deductions, and the ability to create messages for communication with the server.

Driving Analytics: Based on statistics from the sensors and battery and stores them in local memory for transmission to the server once a day for further processing and analytics.



CLOUD SIDE TECHNOLOGY STACK

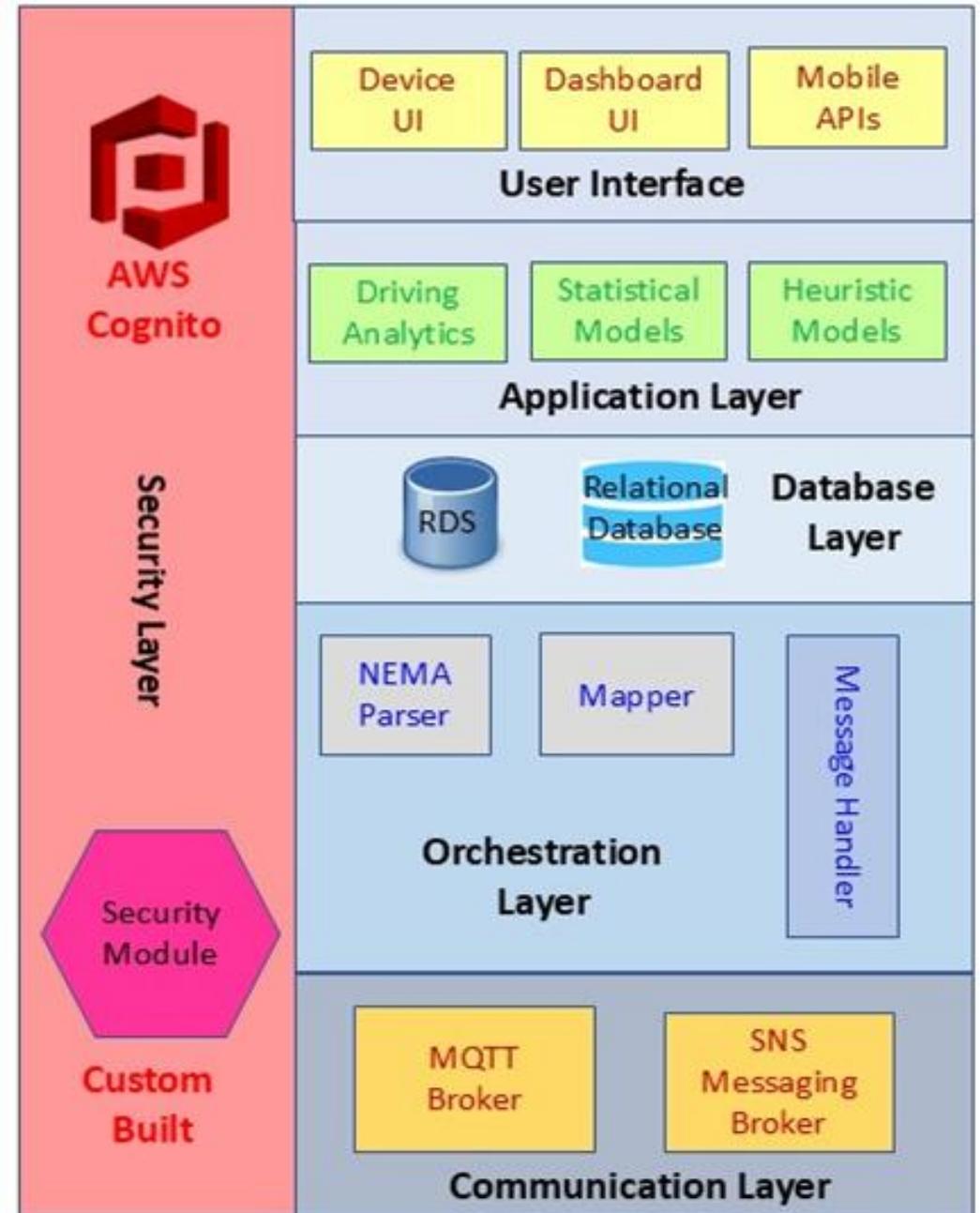
Communication Interface: Functionality for communicating with devices using an MQTT broker, SMS Gateway, AWS SNS, and custom build code.

Orchestration Layer: For interaction among various application components and the messages received from the devices to ensure that application takes the required action based on alerts and messages.

Application Logic: consists of business logic and AI models. These modules are developed based on proprietary algorithms (Heuristics and Statistical Models) to take appropriate action in case of an event (accident).

Database: RDS for user authentication and authorization. It uses a Relational Database to store all messages received from different devices (Smart Helmets) and other system objects.

Security Layer: Protects against spoofing and unauthorized access to system resources and information stored in the database.



AI USAGE EXPERIENCE

- Rule based input-output techniques resulted in false positives and negatives.
- The accuracy was 60% in the best of cases.
- This was unacceptable, so we experimented with multiple supervised learning models to improve the accuracy.
- The models considered were Random Forest, Support Vector Machine, Naïve Bayes Classifier, and Convolutional Neural Network (CNN).
- Since it was necessary to find the patterns that determine a particular action (i.e., accident), we found the performance of CNN the best.
- The accuracy improved from 60% to 98.5%. We used a dataset with 12,500 observations at different locations to evaluate the models.
- Out of the total dataset, 80% were used for training and 20% for evaluation.

- **Expanding Usage:** can be extended to the soldiers on the battlefield to detect any health issues, such as concussions resulting from blasts.
- **Regular Software Updates and Patch Management:** to improve security and minimize vulnerabilities of IoT devices.
- **AI and Machine Learning:** to gain insights and make predictions. AI processing can be done on Edge devices with more processing and storage capabilities.
- **Efficiency:** Reduce energy consumption and improve comfort.
- **Cost Reduction:** current around \$300

FUTURE NEEDS